METHOD FOR A COMMON EVALUATION OF PETROGRAPHICAL AND PALEONTOLOGICAL INVESTIGATION OF DETRITAL SEDIMENTARY FORMATIONS

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РЕЗЮМЕ

Состав некоторого пространства отложений, свойства его отдельных составляющих и петрологические характеристики накопившихся отложений определяются в основном теми же самыми физическими и химическими параметрами. Этот факт обусловит принципиальную основу для совместной интерпретации результатов петрологических и палеонтологических исследований фаций. В качестве основы для совместного исследования можно взять выявление гидродинамического характера среды переноса и отложение вещества и физического состояния области отложения. В качестве петрологического метода может быть применено исследование диаграмм логарифмической вероятности распределенны зёрен. С помощью этого метода легко могут быть определены свойства движения обломков, характерных для более ранных районов накопления, размеры по разному накопивщихся зёрен, а также и их количественные пропорции. Эти характеристики обосновывают выводы относительно характера и интенсивности движения воды а также и консистенции области отложений. Палеонтологический метод исследования оприается также на определение в основном этих характеристик, следователно, два упомянутых метода могут быть применены параллельно. В работе приводится совместная интерпретация двух методов исследования фаций, на примере обработки материала с профилей обломчатых отложений третичного периода в районе гор Черхат (Северная Венгрия).

Introduction

Existence and development of living organisms is inseparable from the physical-chemical state of their environment. These factors determine by and large also the processes taking place after their fading away and after their embedment. In the case of hydrobiosphere the lifeless environment is mostly represented by the sediment-collecting terrain and/or by the medium transporting and depositing the sedimentary matter. So the composition of the biocenosis, the features of the individual member as well as the petrographical character of the matter accumulated within the environment of the given biotope, respectively of the matter deposited out of the given medium will be influenced by and large by the same characteristics of state. Thus we may well expect a close connection between faunistical, floristical and sedimentological features and this is supported also by the study of sediment-collecting terrains, respectively life-spaces of tody.

Salinity, temperature, as well as the transillumination are influencing significantly the biocenosis, thus usually they can be well reconstructed from the analysis of the latter. The connection between these factors and the petrographical features of the detrital formations is rather loose and it is more difficult to be investigated. For the structure of the surrounding dry land as well as for its crustal constructional state one can get information from the mineral composition and from the shape and size of grains. Such immediate informations are seldom provided by the paleontological material, thus in this connection a parallel study of paleontological as well as petrographical features presents certain difficulties. Organic life as well as the sediment accumulation is significantly influenced by the life space, respectively the *hydrodynamical, energetical* features of the detritus depositing or transporting medium. Since it is in immediate connection with the water depth, with the distance from the shore and with the morphology, i.e. with the factors basically influencing the paleontological and petrographical character of a sedimentary formation developing at a given place, the investigations of facies particularly emphasize the reconstruction of this characteristics.

The paleoecology – investigating the features of form, frame structure, feeding, positioning and change of place of the one-time biocenoses – draws conclusions – among others – to the water movement, the consistency of the sediment, the intensity of transport of detritus and in way this to the mentioned environmental conditions. A similar aim is pursued by the petrographical facies-investigating methods making use also of these characteristics in connection with the hydrodynamical-energetical features.

Neither the paleontological, nor the petrographical facies investigations are able to eliminate certain sources of error stemming either from principle or practice, which can weaken the value of the conclusions drawn in various manner. The effectivity could be improved by a simultaneous application of several paleontological and petrographical facies investigating methods taking into account various aspects and so complementing each other. Nevertheless, very little progress has been made up to now in this direction, especially concerning detrital sedimentary formations. Paleoecologists are attributing a great significance to the petrographical features, but in the course of their works they seldom go beyond such general statements, as "sandy", "clay", "slity" etc., or beyond a mechanical documentation of grain distribution investigations. The cause for this is lying in the imperfections of the possibilities provided by the petrographical investigating and evaluating methods. Thus far, no such evaluation method has been gaining ground, which could easily be implemented, consequently could have a widespread application and which would support the paleoecological partial results by means of individual sedimentological data. The petrographical methods used thus far – providing often rigid results of final conclusional character – are hardly to be used for such a purpose.

Basic principles of the possibility of joint paleontological and petrographical facies-investigations with common point of view

On the basis of what was outlined above it is clear that common aspect of paleontological and petrographical facies analysis may be the investigation of the hydrodynamical character of the transporting and depositing medium and that of the physical state of the sediment collecting terrain. A grain distribution investigating method well to be used for this purpose was discussed earlier by the author (J. Andó, 1973), so that here only ist basic principles will be given.

Based on a detailed investigation of the grain-size distributions Doeglas, D. J. (1964), then Pettijohn, F. J. (1949) realized that these can be broken up into two or more partial distributions – populations – formed by different transportand sedimentational conditions. The explanation of this connection by physical and hydrodynamical notions is due to Inman, D. L. (1949). He stated that the transport of detrital grains has three main forms: a surface slipping-rolling, a saltatory and a suspension – form. The individual grain groups representing the single transport-deposition- forms show lognormal distributions, so that on the distribution diagram showing lognormal probability values they present themselves as straight sections of the composit distribution curve. This sections are characterized by different slopes

– due to the different energetical and classifying features of the factors forming the individual populations – thus they can well be separated (Fig. 1.).

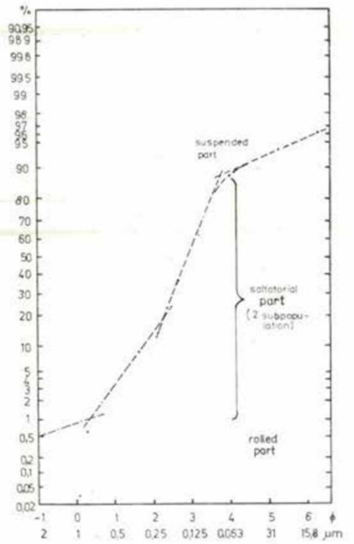

Fig. 1. Log-probability distribution of transport-sedimentary grain components

In the domain of greatest dimensions we find the population representing the material transported by rolling. This portion – being absent in cases – is usually represented by a single section of straight line. Within the domain of smaller dimensions the distribution section represents the grains transported by saltations and this classifies itself into one or two subsections. The bipartite saltatory population is characteristic to the littoral flat-shore terrain. Its development can be explained – also according to the recent experiments of K o l m e r J. R. (1973) – by the periodically changing direction of the water movement prevailing here, which is – as it is widely known – of a variable transporting and classifying capacity. The sedimentary material in suspension produces a straight line section of distribution in the domain of fine grains (Fig. 1.).

Thus using this method one can determine the character of the movement of detritus corresponding to the environment of the one time accumulation terrain and the dimension of the grains deposited in the various ways, as well as their shares in quantity. (V i s h e r , G. S. 1969) From these indicators we can draw conclusions regarding the character of water movement, its intensity, the consistency of the sedimentary terrain and its debrismaterial content. The paleontological investigation methods also largely rely on the determination of environmental conditions (L. B o g s c h, 1968, T. B á l d i, 1973).

For the appearence of *epifauna* a relatively rigid bedding is needed, the development of which is possible only above a certain grain size. Water flowing with a critical speed corresponding to this greater grain size (J. B o g á r d i, 1971) transports away most part of this detrital material, so the rate of sediment accumulation becomes lower. In a water with strong mobility the material transported by suspension and partly also that transported saltatorily is of uniform distribution, the concentration of the detrital grains – indicating a tendency towards deposition – is slight. All this results in a clear water enabling at the same time an alimentation with *filtering of suspension*. These conditions are indicated on the log-probability cumulative grain distribution curve by the prominent appearence of the section corresponding to the rolled component.

For the existance of *infauna* the presence of a more loose, finely grained sediment is necessary which enables the living beings to dig themselves in to the basement. In this framework we can make further refinements regarding the environment of the one-time living-space basing on the analysis of the way of feeding. The presence of the suspension-filtering infauna is characteristic of a flowing, clear water environment. Under such conditions the basement is made of a sediment with medium grain size and eminently rolled as well as saltated parts the role of the suspension grain population, however, is becoming more and more apparent.

To the way of life of the silt devouring infauna a sediment rich in organic matters is necessary. The accumulation of this may take place in a slightly aerated and moved water from a very fine grained suspension. Thus these formations are characterized by a grain distribution with high proportion of suspension parts.

The organisms digging themselves into the sediments and especially the silt devouring ones in the course of their life-functions are stirring up and intermixing the debris deposited in the various levels (bioturbulence). Owing to this the grain distribution being originally corresponding to the existing hydrodynamical features may be distorted and a mixing up of the single grain populations can be observed. This is indicated by the rounded off parts of the curves at the intersections of the straight sections representing the various types. In case of a more strong mixing and reaccumulation – e.g. in case of a drastic matter-rearrangement characteristic to the turbidites – one can not draw any conclusion to the primary accumulation terrain on the basis of the grain distribution. In that case the facies investigations may rely first of all on characteristics of the rockstructure and stratification.

With these we have outlined the general connections only; for the solution of paticular problems detailed, individual analysis are needed. According to the above discussed principles the method can be applied of course only in case of a simultaneous paleographical and petrographical sampling. We have to make efforts – especially in case of finely or rhitmically layered sedimented complexes – to provide samples with as small a time unit as possible, i.e. samples representing as homogeneous developing conditions as possible.

Complex facies investigation of the loose sandstone series of Iliny

The possibility of a common valuation of paleontological and petrographical points of view will be shown on the example of the investigation of the fine sand complex from the surroundings of Iliny. Regarding the stratigraphical conditions of this formation – as well as regarding all the sedimentary series of the Northern–Cserhát – no uniform attitude has been taken for a long time in the relevant technical literature (I. Ferenczi, 1939, F. Horusitzky, 1939, J. Noszky sen., 1940). The removing of contradictions has been made possible only by the recent faunistical- stratigraphical (T. Báldi – M. Horváth, 1971, M. Horváth, 1972, T. Báldi, 1973) as well as by the petrographical invetigations (I. Kubovics – J. Andó, – Mrs. Nagy, J. Balogh – Mrs. PécsiÉ. Donáth – J. Rózsavölgyi, 1971). According to T. Báldi the upper Oligocene (Egerian) containing in the Western – Cserhát mostly shallows sublittoral, reduced salt-watery and littoral intercalations towards east turns step by step into a medium-deep-sublittoral, shallow bathyal facies. Westwards, after the development of a fine-grained as well as coarse-grained, aleuritic sandstone of the Oligocene a turning into continental land is encountered – owing to regressional tendencies – while Eastwards – on the deeper parts of the sedimentary basin – we can see a continuous sedimentation up to the end of the lower Miocene. Corresponding to this the lower section with finer grains of the so called "streaks" (of Szécsény) which developed on the deepest basin parts accumulated in the upper Oligocene, while the somewhat coarser grains forming the upper section accumulated in the lower Miocene (Eggenburgian). On the areas of the sedimentary basin nearer to the shore (Westwards) the continuous Oligocene-lower Miocene sedimentation resulted in layers of variegated development connected laterally with the "streak" – series. A characteristic representative of these formation is the loose sandstone series of Iliny of some 100 m thickness; its layers have been deposited in the deep gorge southwards of Iliny on the lower parts of the streaks of Szécsény with continuity of sedimentation (Fig. 2.). The overlying rock is probably the continental-paralic coal bed series (I. Ferenczi, 1939), which had been one time explored towards SE. Thus, following the development of the lower section of the streak of Szécsény the gradual regression developed through the sandy-aleuritic series up to the full emergence.

The biostratigraphical investigation of the series has been made by T. Báldi and M. Horváth, 1971: in the course of my studies I took all the faunistical, biofaciological basic data from this work. According to the above mentioned authors besides the gradual petrographical development of the series from the streak of Szécsény the development

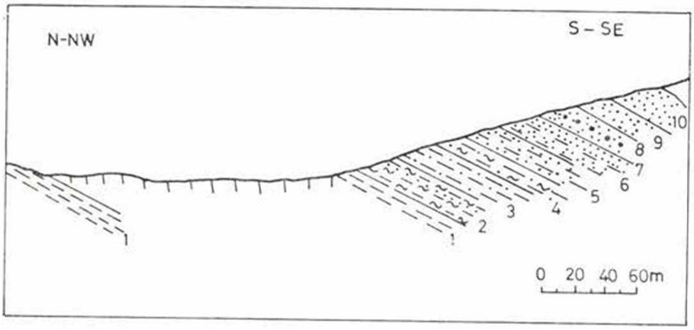

Fig. 2. Geological profile of the Iliny-gorge (after T. Báldi, 1971)
Legend: 1. Lower section of the fine grain, aleuritic Szécsény-streak series; 2. "Transitional layers" between the Iliny-sandstone and Szécsény streak series: fine-grain ed sandy, clayey aleurite with sandstone embedments; 3. Yellow fine-sandstone-aleurolite; 4. fine-sand aleurolite; 5. layered loose sandstone-aleurolite; 6. fine-grain loose sandstone, with 1 cm aleurolit embedments; 7. whitish grey aleuritic , fine grained loose sandstone; 8. gravely fine-grained loose sandstone; 9. fine-grained sandstone; 10. yellow, aleuritic fine-grained loose sandstone

of the fauna shows also similar transitions. The first layer of Fig. 2. proved to be also faunistically the bathysyphonic section of the streak of Szécsény. But the layer 2. is "transitional on the one hand between the streak of Szécsény and the sand of Iliny, and on the other hand between the Egerian and Eggenburgian". The above mentioned authors consider the "transitional fauna provisionally as the uppermost part of Egerian" and so they set the "frontier of the Egerian and Eggenburgian, i. e. of the Oligocene and Miocene" between the layers 2. and 3.

In the bathysyphonic streak (layer 1.) forming the deepest part of the studied profile silt devouring fauna prevails. This indicates the presence of a "soft, silty basic layer" and of a very weakly moved sedimenting medium. The frequency of euryoxibiontic forms and the absence of herbivorous organisms indicate the existence of a greater water depth and larger dis tance from the shore. According to the grain size investigations this formation consists of a saltatory population of a relatively low frequency (20–30%) and restricted to the fine grain domain, and in the most part of a suspension grain component which is very steep (Fig. 3.). This characteristics – in agreement with the faunistic results – point to a very weak bottom flow and to a sediment accumulation consisting of grains mostly floated in a hardly moving medium. On the grain distribution diagram we can see a double break which can be attributed to the mixing influence of the silt devouring organisms.

The so called "transitional layers" (Fig. 2., 2.) can not be separated on the basis of their external appearence from the streak of Szécsény forming the basement. The prevalence of the silt devouring infauna indicates also a biotope basically similar to the earlier ones. To the chang- of physical factors we can conclude from the appearence of populations indicating the presence of a smaller sea depth of 30 – 50 m. This change can be traced also on the basis of grain size distribution investigations (Fig. 3., 2.): the quantity of saltatory grains has increased significantly (80%) but ist weaker classification and the still significant suspension part indicate the weak influence of water movements (waves, flowing). On the basis of these characteristics as well as owing to the absence of rolled grains no smaller sea depth than that of a sublittoral one can be supposed.

The macrofauna of the ensuing levels (Fig. 2:3 – 10) deviates signifacantly from those discussed above, both in stratigraphical, as well as in faciological character. But "the difference was not formed at once ..., going upwards one can observe the staying out of the latest streak faunas." The gradual change of the sediment-accumulating terrain becomes apparent also on the basis of grain-distribution studies. Within the grain distribution of the 3. layer (Fig. 3.) – although to a small extent at first – the slipping population has also developed. The saltatory grain component is well classified and gives 90% of the distribution. The lower dimension limit of the floated grains is 40 μm, their quantity is only 10%. These characteristics indicate definitely an enlivened water movement. But the dimensional domain of the saltatory population bears witness to an accumulation environment with a relatively distant shoreline and to a somewhat greater depth than that of the shallow-sublittoral, coarsegrained zone.

A vigorous change of the fauna picture sets in within the layer 4. (Fig. 2.). The appearence of supension-filtering molluscs en mass indicates

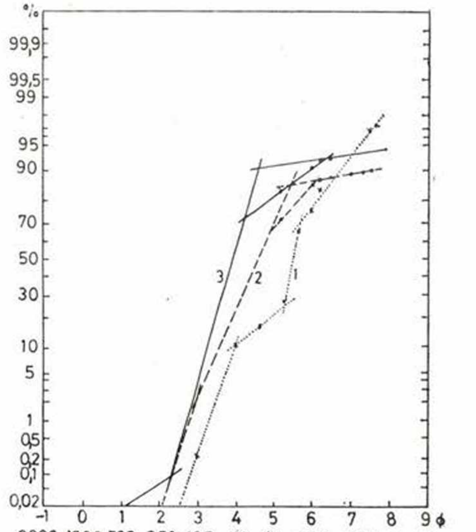

Fig. 3. Log-probability grain distribution of the formations exposed on the lower part of the Iliny-gorge (denotations as on Fig. 2.)

a well defined water movement. The "infauna" characteristics as well as the further presence of "silt devouring streak formes" point to a soft basement. This later phenomenon proves also the graduality of the change of sedimentation terrain and that of the exchange of the fauna. According to the grain distribution investigations the gradual change took place through smaller oscillations of energy conditions and thus, of the debris-transporting and sedimenting conditions. In the layer-components of the above discussed level 3. and of the somewhat deviating level 4. — as regards their composition — the very characteristic form of the curve does not change, although we can observe differences in the average grain size, the quantity of the suspension population as well as in the appearence of the slipping grain component (Fig. 4.). This variability — being very characteristic for the lower part of the sublittoral zone in general — is in agreement with the paleontological observation outlined earlier. The significant quantity of saltatory population and its dimensional domain of 0,25 – 0,03 mm shows a vivid water movement, but a still soft, fine grained basement. This duality can also be established from the appearence of a small amount of rolled grains besides of the still significant suspension component. The lability of sedimentational conditions is extremely apparent in the layers 5. and 6. — in form of micro-layering. The grain distribution of layer 6. shows (Fig. 4.) a broad mixing interval, as well as a restricted steepness of the saltatory component, which can be explained by the mixing of the single microlayers in the course of sedimentation, or — owing of the work of silt-digging

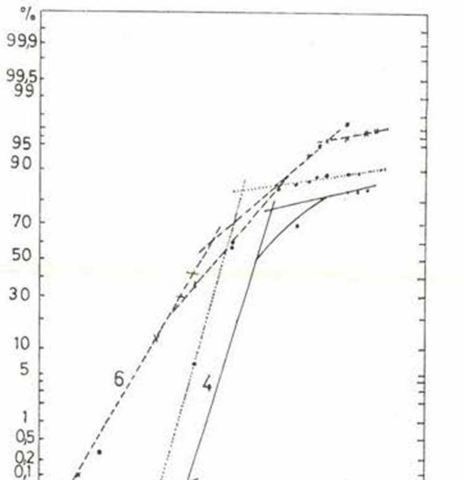

Fig. 4. Log probability grain distribution of the formations exposed on the middle part of Iliny-gorge (denotations as on Fig. 2.)

organisms – immediately after it (partly, however, by the difficulties of analysing rocks of such facies).

According to the investigations of T. B á l d i and M. H o r v á t h (1971) the "silt-devouring forms ore completely absent already in the upper levels of the spot explored. The tendency of strengthening the flows and the richess in oxygen in connection with it has made less possible the mixing of organic matter with the sediment". Nevertheless, the presence of suspension-filtering organisms digging themselves into the basement points to a still prevailing softness of the bottom. Arder surfaces and slow sedimentation periods could develop only occasionally, which is proved also by the scarcity of epifauna. The form of the grain-distribution curves of these yellow loose sandstone layers reflects the influence of strong wave-motions (Fig. 5.). The increase of the significance of sliding population and the turning point of the saltatory and suspension grain components falling into the domains of coarse grains point to the higher regions of shallow sublittoral zone. Within the saltatory population no break can be observed, thus excluding a shoaling up to the tidal zone. The significant amount of the suspension component indicates a rich material supply. The rollingly transported grains, however, are of relatively smaller dimensions and their amount dos not exceed 25%. This points to a loose (not soft!) basement, which is easily to be stirred over and so it was unfavourable to the development of epifauna. The only exception is presented by the fine-gravelly level of the layer 8. This component represents that formation of the studied series, which has sedimented nearest to the shore.

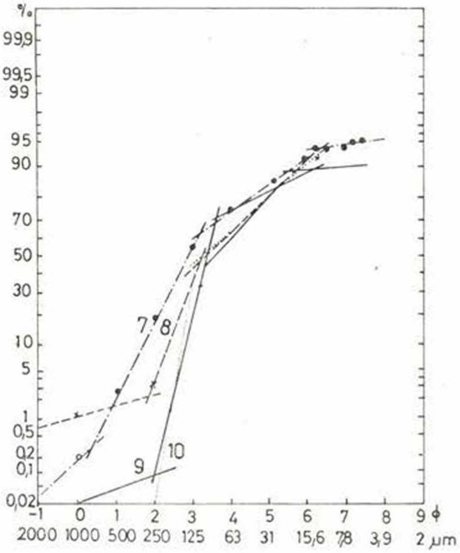

Fig. 5. Log-probability grain-distribution diagrams of formations exposed on the upper part of the Iliny-gorge (denotations as on Fig. 2.)

In the uppermost layers of the series a slight decrease of the average energy characteristic to the sedimentation is observed. The dimensional domain of the grains deposited out of the suspension, however, ist almost unchanged. This phenomenon may indicate that the sediment accumulating spot has become more protected, more closed. In that case, namely, the intensity of terrigenous material supply may remain similar to the previous one also with a weaker water movement, due to the relative nearness of the shore. This process may further lead to a gradual seclusion of the sedimentary basin as well as to its filling in. Though this can not further be investigated in the profile, this concept is supported also by the cover formation of terrestrial character with coal beds mentioned earlier.

On the basis of these consideration one can state that the paleographical and petrographical methods furnish results being in agreement with and completing well each other. The analysis along the profile (Fig. 6.) shows that parallel to the increase of the ratio of saltatory component, respectively of the decrease of the quantity of the matter deposited from suspension (layers 1–4.), the silt devouring forms gradually fall into the background against the suspension filtering ones. In the upper levels of the exposure the share of the saltatory component diminishes, but the prevailing role of the suspension filtering ones remains unchanged. This phenomenon can be explained by the change of average size of the individual grain populations. In the course of our studies we used for the characterisation of the average grain size of the individual populations – as a first approximation – the mean value of the size interval.) The characteristic mean grain size for the Szécsény–streak consisting of sal-

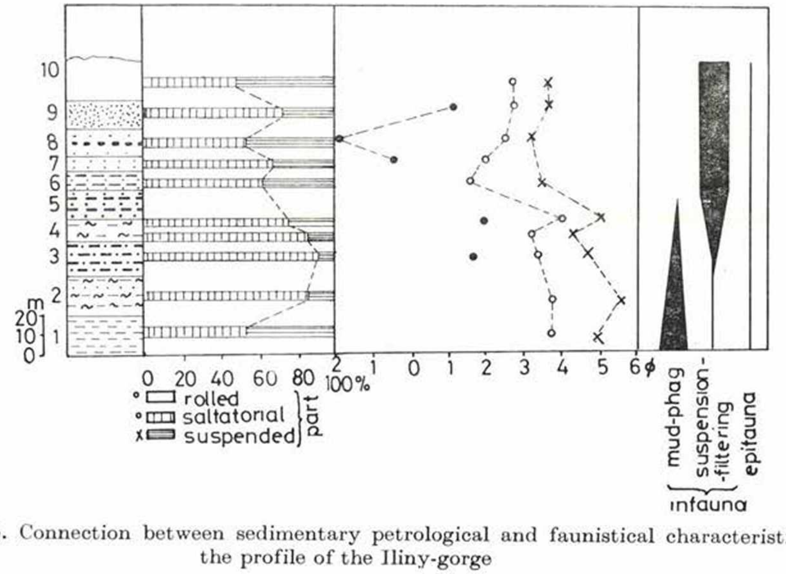

Fig. 6. Connection between sedimentary petrological and faunistical characteristics on the profile of the Iliny-gorge

tation and suspension components in a 50 – 50% ratio is shifting towards the coarser domains in the younger layers – in some places with sharp changes. Together with change of the grain dimension of the two components the saltatory population gains weight in the layers 2. and 3., then upwards from the 4th level the original ratio of 50 – 50% comes gradually back again. Inbetween – as we have indicated – the mean grain size of the saltatory component changes from 3,6 to 2,6 Φ, while that of the suspension component goes from 5 Φ to 3,6 Φ, i. e. to the size of the saltatory population of the Szécsény-streak. Thus, the one time accumulation terrain was characterized by a relatively clear water because in spite of the higher ratio of the suspension component there was stable sedimentary basement corresponding to the way of living of suspension filtering organisms and proved by the coarser grain size. In the continuation of the series, however, it may be assamed by geological analogies, that the filling in tendency went on, thus leading to a possible basic change of the living space and of the fauna.

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